



Earth Observing -1

A Clearer Picture of Our Changing Planet

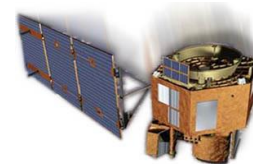
# Earth Observing-1 Status for the MOWG on 2 June 2015

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Presented by Stuart Frye for  
the EO-1 Team



# EO-1 Flight Systems

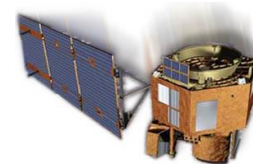


EO-1

- Health and Safety of spacecraft (S/C) and subsystems continuing nominal operations
- Power Systems are working nominally
  - After performing a cycle of VT changes to help condition the battery for longer use (improves state of charge, speed of charge and differential voltage), the EO-1 VT is now set to a VT level of 4.5
- Instruments performing nominally
  - Solar and Lunar Calibrations routine including slow scan Hyperion and a negative phase angle lunar calibration to aid LDCM in calibration
- Out of usable fuel since February 2011 but attitude control system (ACS) fully functional



# EO-1 Mission Enhancements

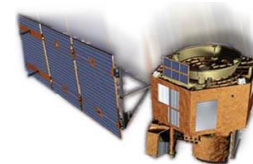


EO-1

- The EO-1 mission is out of usable fuel.
  - The spacecraft is no longer tasked to perform MLT maintenance burns (inclination burns).
- With a transition from MOPS (old) to ASPEN (new) and CMS (old) to SCP (new) mission planning systems, the FOT couldn't initially perform Delta-V maneuvers.
- The FOT created procedures and implemented a way to perform Delta-V maneuvers on the new mission planning systems to perform debris avoidance maneuvers.



# EO-1 Mission Enhancements



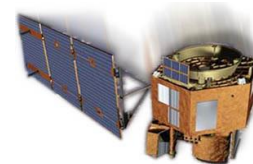
EO-1

- **EO-1 32K TDRS supports**

- EO-1 FOT enhanced the way TDRS passes were used previously by adding 32K TDRS supports
  - All TDRS supports previously were at a slower 4K RTN rate.
  - With faster 32K RTN TDRS supports, EO-1 passes can downlink data much faster compared to the 4K supports.
  - EO-1 FOT is working on modifying goal upload logic so that goals and sensor-webs can be uploading by ground automation during 32K TDRS supports thus increasing imaging and house keeping capabilities.
  - Requested White Sands to add 32K RTN TDRS related SSC codes in SNAS. With dedicated SSC codes, the EO-1 FOT can now quickly schedule 32K TDRS supports
    - All 32K RTN TDRS related SSC codes have been added for the EO-1 mission.



# EO-1 Mission Enhancements



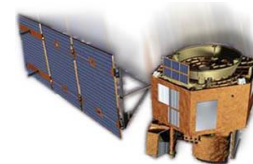
EO-1

- **EO-1 Lunar Calibration Modifications**

- EO-1 FOT created a way to perform a single scan Hyperion centered lunar calibration
  - This calibration is performed prior to a positive phase nominal 4 scan lunar calibration
- Singled out all atmospheric corrector (AC) commands and reduced the nominal 5 scan positive phase lunar calibration to a nominal 4 scan positive phase lunar calibration (removed all AC scans/commands).
- Conducted negative phase lunar calibrations in conjunction with Landsat Data Continuity Mission (LDCM)



# EO-1 Debris Avoidance Maneuver

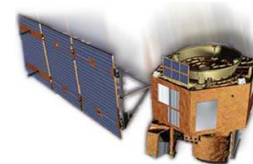


EO-1

- The EO-1 spacecraft had a close approach with a (FENGYUN 1C DEB) on 5/10 at 17:57:40 GMT
  - Miss distance of ~167m
- The EO-1 FOT team was asked to perform a 10 second Delta-V maneuver on May 9<sup>th</sup> at 13:30 GMT.
  - The Burn was successful, the spacecraft thrusters fired for the full 10 seconds.



# EO-1 New Ground Stations



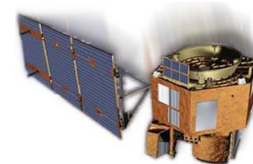
EO-1

- EO-1 Flight Operations Team (FOT), Earth Observing Systems (EOS) Data and Operations System (EDOS), Near Earth Networks Services (NENS), Universal Space Network (USN), and Wallops and White Sands scheduling personnel worked to switch from PF1/PF2 to Northern Alaska ground stations
  - testing of S-band uplink/downlink, X-band downlink, and telemetry tracking for new ground stations in northern Alaska designated USAK-02/03/04
  - coordination of firewall rule updates
  - conducting test passes over the new ground stations
  - implementation of modifications to the ground and flight software to point the satellite antenna at the correct locations
  - analysis of the command link, telemetry receipt, science data capture, and ranging/tracking data files for operational readiness





# EO-1 Recent Anomalies



EO-1

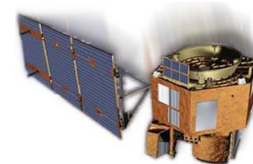
- **Low Voltage Anomaly (concluded)**

- The battery was nearly up to full charge by the end of that first daylight period and was at 100% 10 minutes before the end of the second sunlight period after the anomaly
- Nominal Lunar Calibrations have been steadily hitting lower voltages over the past few years, so after analysis by the GSFC Power Branch, it was determined that the TSM red low limit could be lowered from 25.5V to 24.75V before invoking safhold while still maintaining adequate margin
- The FOT prepared and uplinked an update to the relevant TSM table on 11 March 2014
- A nominal Lunar Cal at the next full moon was executed routinely on 17 March 2014





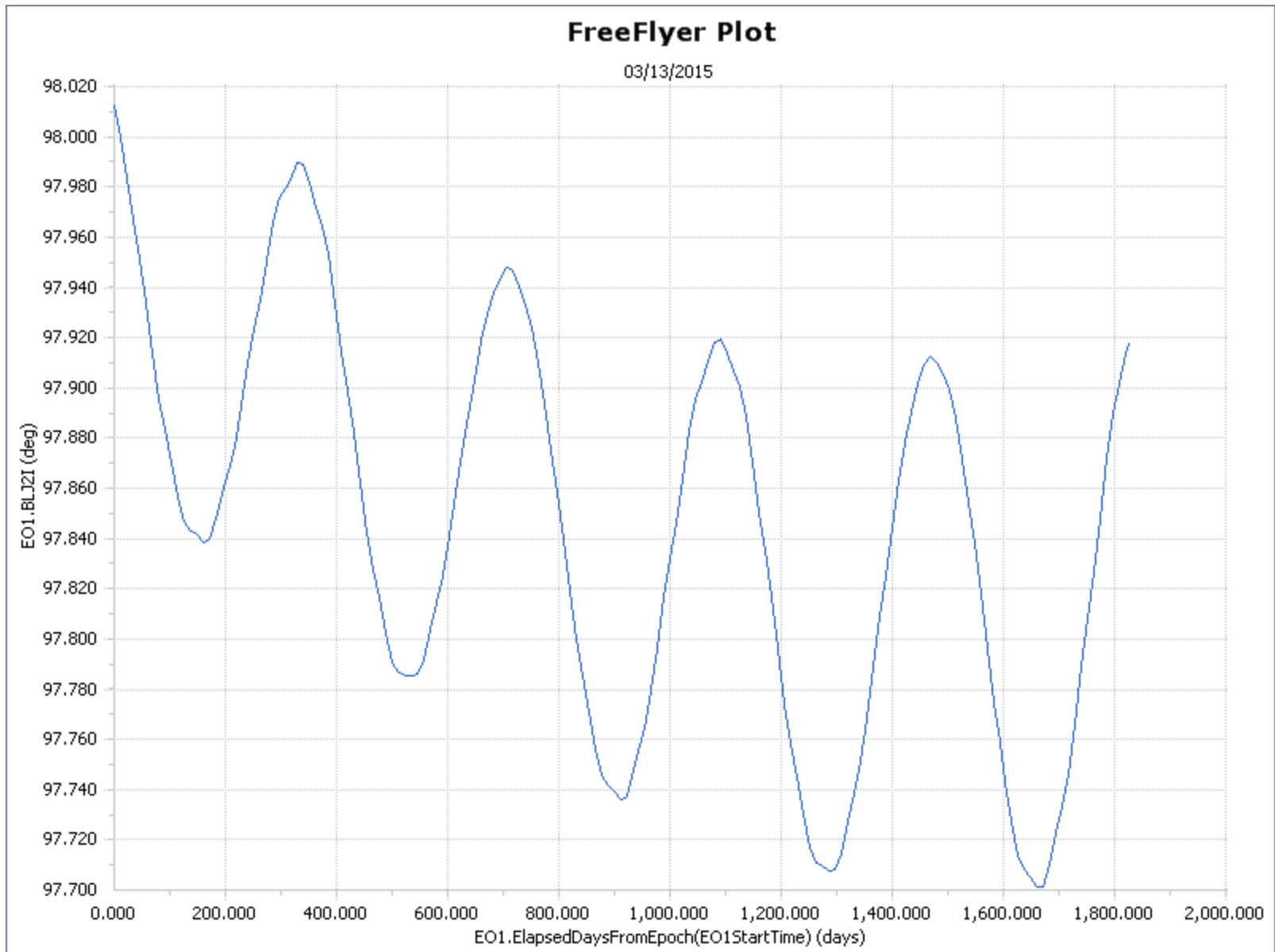
# EO-1 Orbital Information



EO-1

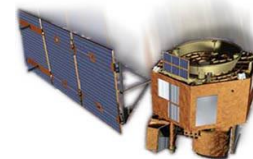
- EO-1 Orbit Information on 03/13/15 00:00:00z
  - Semi-major Axis = 7065.655 Km
  - Eccentricity = 0.000545
  - Inclination = 97.936 Deg
  - RAAN = 338.705 Deg
  - Argument of Perigee = 50.504 Deg
  - True Anomaly = 137.525 Deg
  - Altitude at Apogee = 691.366 Km
  - Altitude at Perigee = 683.669 Km

## Earth Observing-1 Inclination Status for the MOWG



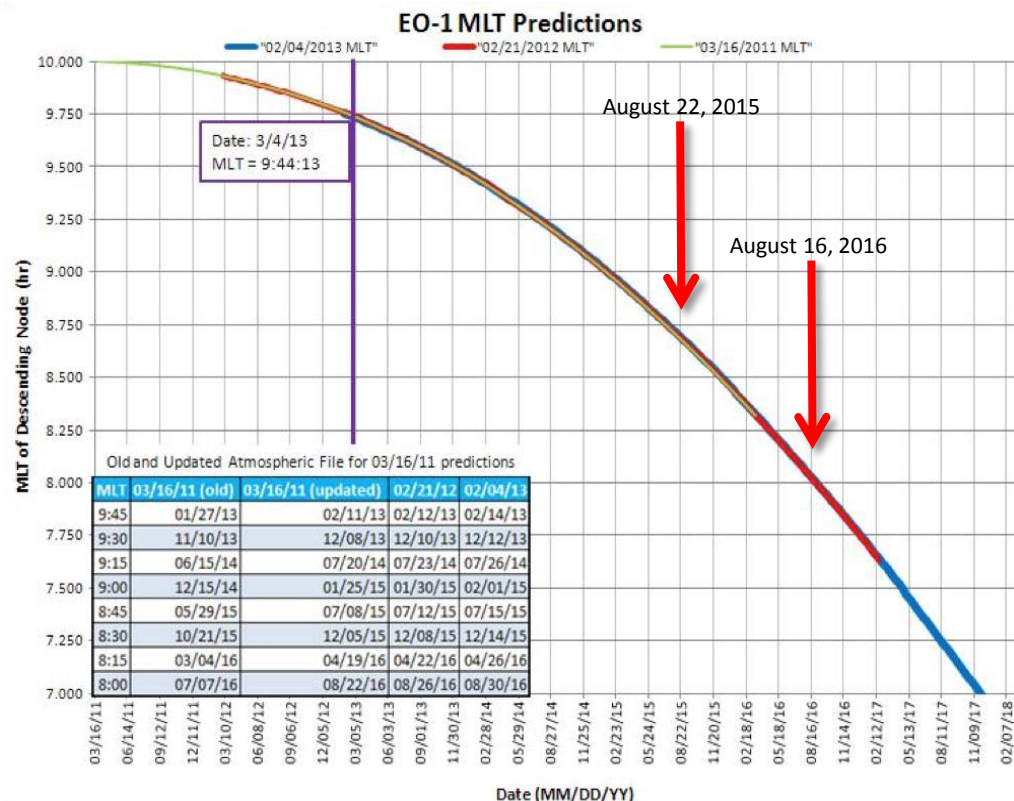


# Comparison of March 2013 Senior Review MLT Projections with March 2015

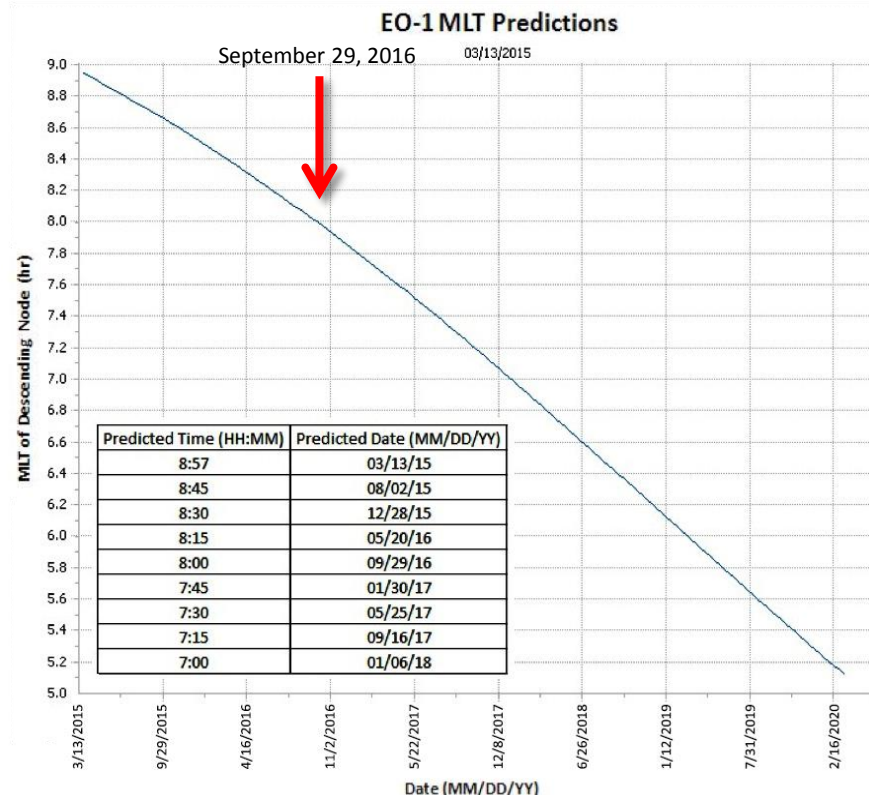


EO-1

*Shows orbital projections have been consistent and  
that earlier predictions were too conservative.*



*Orbital Projection from March 2013  
Senior Review Proposal*



*Orbital Projection from March 2015  
Latest Calculations*

This EO-1 MLT and SMA analysis was independently  
verified by the Terra, Aqua, Aura Flight Dynamics team.

## ALI data taken at an 8 AM equatorial crossing time is valuable in spite of the decline in SNR

- The ALI SNR is inherently 6 to 10X (~800%) that of ETM+.
- The ALI signal at 8 AM always exceeds 50% of the 10 AM.
- ALI SNR at 8 AM will be 3 to 5X better than that of ETM+ at 10 AM.
- **EO-1 will not reach an 8 AM crossing time until October 2016.**

Crossing Time at Equator	March 22		June 22		September 22		December 22	
	Elevation (degrees)	cos(SZA)	Elevation (degrees)	cos(SZA)	Elevation (degrees)	cos(SZA)	Elevation (degrees)	cos(SZA)
8:00 AM	28.3	0.47	26.9	0.45	31.8	0.53	27.7	0.46
8:30 AM	35.8	0.58	33.5	0.55	39.3	0.63	34.3	0.56
9:00 AM	43.8	0.69	40.1	0.64	54.3	0.81	40.8	0.65
9:30 AM	50.8	0.77	46.3	0.72	46.8	0.73	47.0	0.73
10:00 AM	58.3	0.85	52.3	0.79	61.8	0.88	52.9	0.80
12:00 PM	88.14	1.00	66.57	0.92	88.17	1.00	66.57	0.92
<b><u>Signal@8 AM</u></b> <b><u>Signal@10 AM</u></b>		<b>0.56</b>		<b>0.57</b>		<b>0.60</b>		<b>0.58</b>

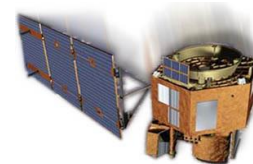
*Signal (i.e. solar irradiance) is a function of the cosine of the solar zenith angle (SZA).*



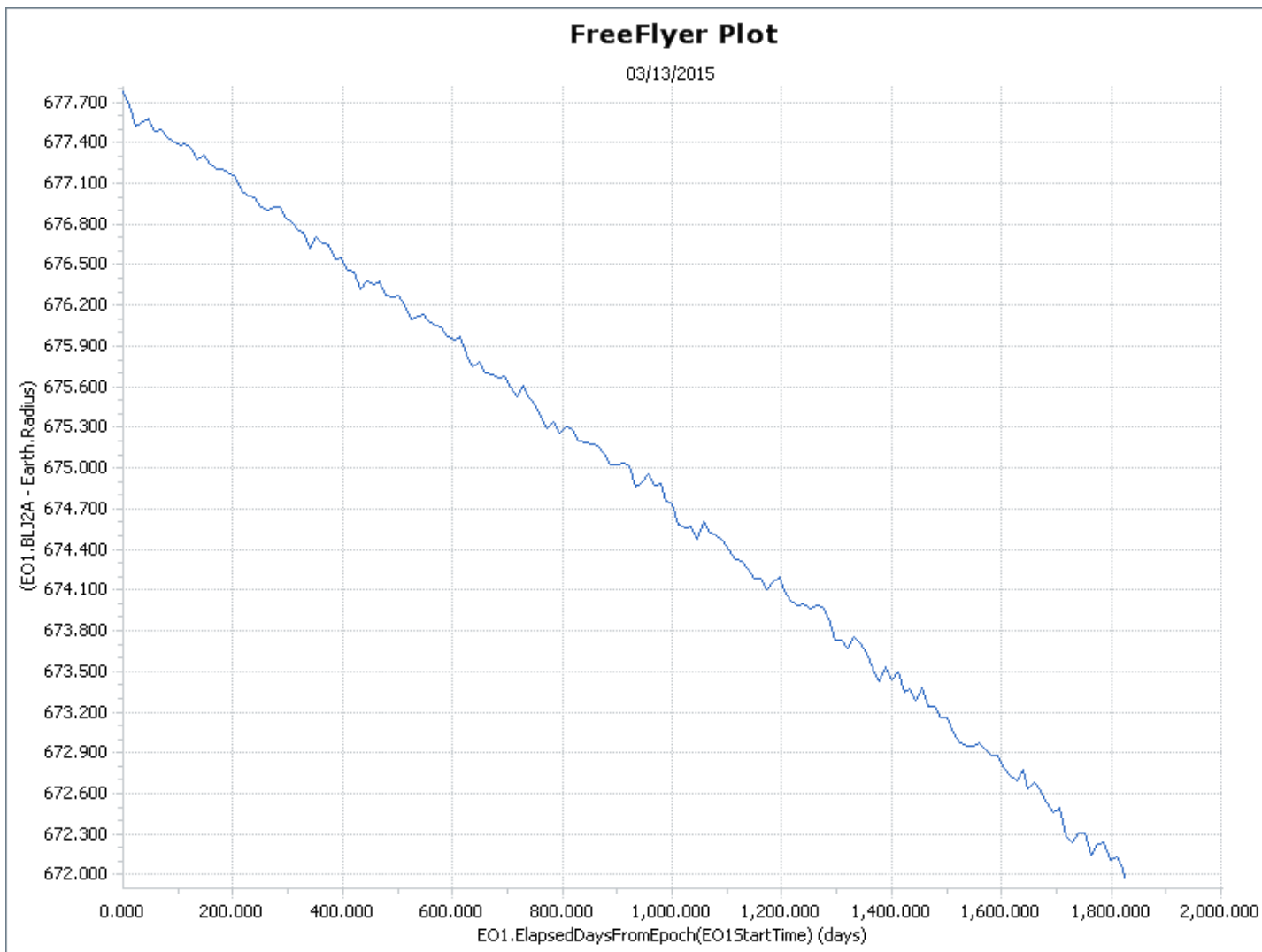
# EO-1 Orbit Plots 5 Year Outlook

## Semi-Major Axis Altitude

(0.00 = 03 March 2015)



EO-1

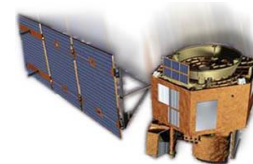




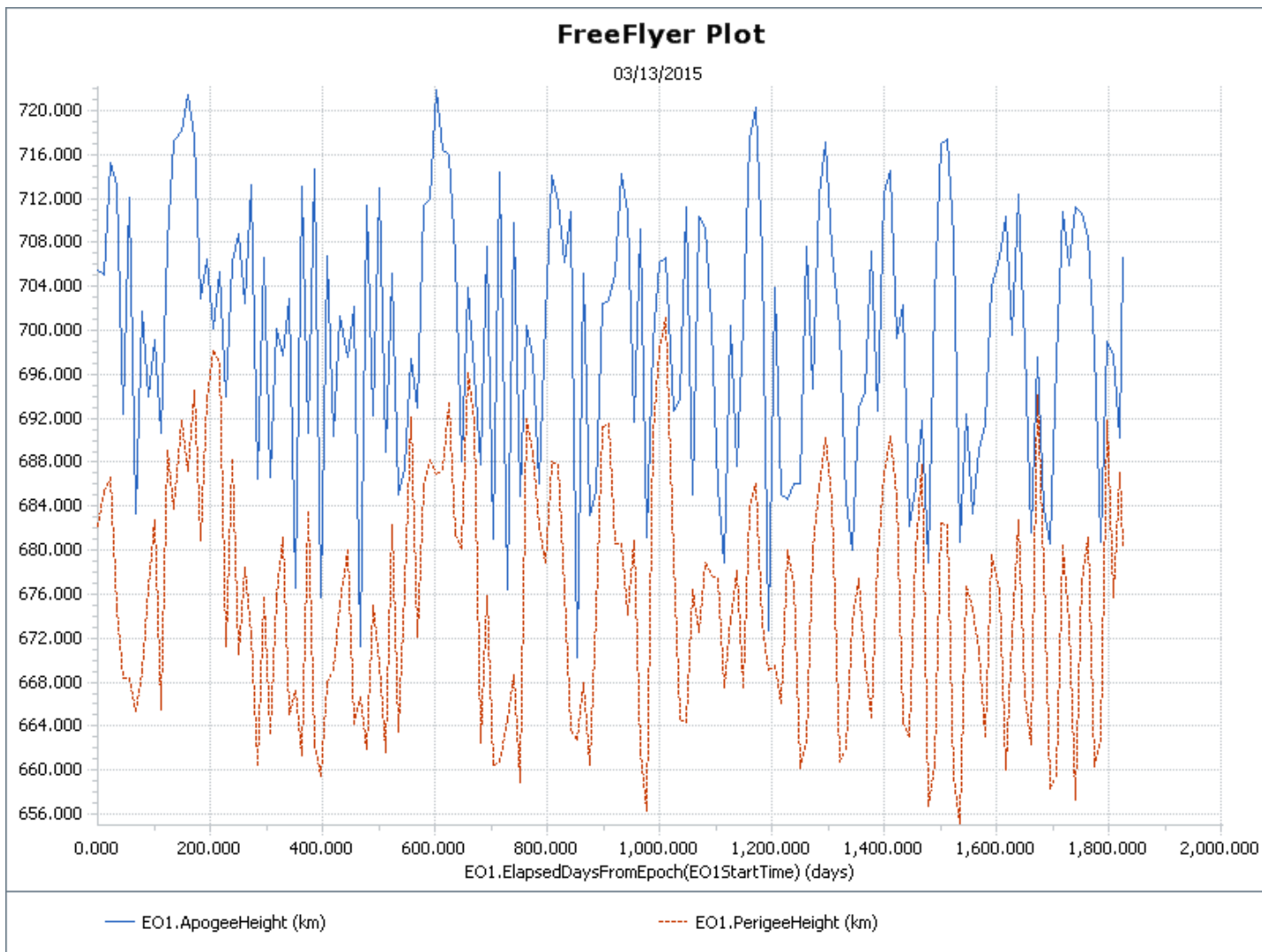
# EO-1 Orbit Plots 5 Year Outlook

## Apogee and Perigee Altitude

(0.00 = 13 March 2015)

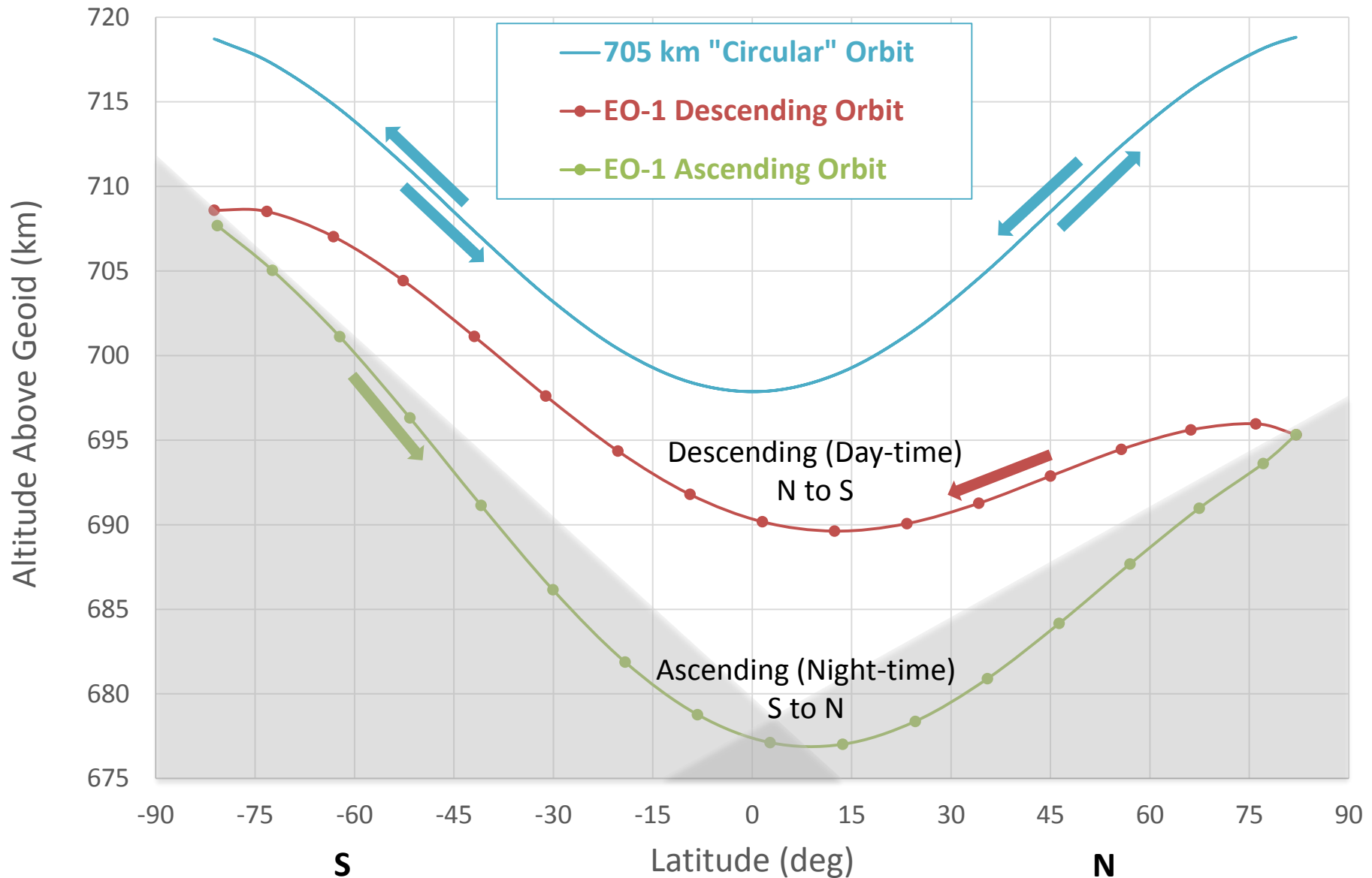


EO-1



# EO-1 Altitude as a Function of Latitude

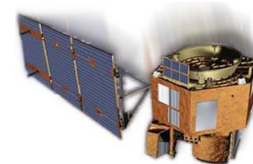
(for the first orbit on January 4, 2015)







# EO-1 Ground Systems

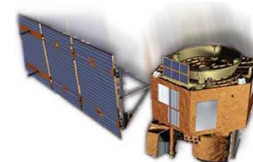


EO-1

- All four Telemetry & Command (T&C) strings working nominally
  - Successfully performed a contingency test utilizing Backup Front End Data System and the 4<sup>th</sup> String T&C system with both ground station and TDRS
- Front End Data Systems primary and backup working nominally
- Data Processing primary and backup working nominally
- Housekeeping Telemetry Processing primary and backup working nominally



# EO-1 Ground Systems



EO-1

- Flight Dynamics primary and backup workstations functioning nominally
  - Added TR2 tracking data parameters to allow TR2 tracking data file (TDF) processing
- Mission Planning primary and backups (both ASPEN and ASIST SCP) working nominally
- Central File Hub primary and backup working nominally
  - Continuing to add more incoming file transfers to the Central File Hub, and removing the previous path as they are tested successfully



# Future NASA Budget Outlook



EO-1

- Senior Review Proposal for full operations support during Fiscal Year 2014 and 2015 approved by NASA Headquarters on 1 July 2013
- Proposed full year of operations during FY2016 with decommissioning starting October 2016 or later
- Phase F report version 2 for decommissioning management starting October 2016 submitted to NASA Headquarters 7 April 2015